Deposition and Trial Testimony of Richard Lee

Case Name	Court	Case Number	Testimony Date	Testimony	Case type
Gallington v. Union Pacific Railroad Company	In the Superior Court of state of California in and for the County of Kern	Cause No.: 240161 RJA	4/26/2001	Deposition	Personal Injury
Floyd Douglas, Jr., et al vs. North American Refractories Company, et al (Adams v. North American Refractories Company (Brooke County, WV)	In the District Court of Orange County, Texas - 128th Judicial District	No. A-920, 961-SC(14)	4/16/2001	Deposition Telephone	Asbestos PI -- Product ID
Flexitallic Gasket Testing (Roth Matter)	In the District Court of Jefferson Co., Texas 58th Judicial District	Cause No. A-161, 748	4/16/2001	Deposition	Asbestos PI -- Gaskets
Baumbauer v Cunningham-Barisic Development Corp. (AKA Village Oaks AKA Palisades at Village Oaks)	Superior Court of the State of California for The County of San Bernardino	RCV-35753	3/8/2001	Deposition	Concrete failure
Herman Wells, et al vs. United States Gypsum Company, et al (Flexitallic Gasket Testing)	In the Distric t Court of Jefferson County, Texas	Cause No. A-161, 748	2/7/2001	Trial	Asbestos PI -- Gaskets
Hoffman, Barbara et al. vs. USX Corporation, et al.	United States District Court Northern District of Georgia - Atlanta Division	1:98-CV-745-TWT	12/13/2000	Trial	Asbestos PI -- Transport exposure

Deposition and Trial Testimony of Richard Lee

Case Name	Court	Case Number	Testimony Date	Testimony	Case type
Barbanti v. W.R. Grace Company (WRG)	Superior Court of the State of Washington for Spokane County	No. 00201756-6	11/30/2000	Hearing	Asbestos PI -- Class Action
Hoffman, Barbara et al. vs. USX Corporation, et al.	In The United States District Court for The Northen District of Georgia Atlanta Division	98-CV-745-TWT	11/21/2000	Deposition	Asbestos PI -- Transport exposure
Barbanti v. W.R. Grace Company (WRG)	Superior Court of the State of Washington for Spokane County	No. 00201756-6	10/23/2000	Deposition	Asbestos PI -- Class Action
Barbanti v. W.R. Grace Company (WRG)	Superior Court of the State of Washington for Spokane County	No. 00201756-6	10/17/2000	Deposition	Asbestos PI -- Class Action
Port Authority of New York and New Jersey et al v. Affiliated FM Insurance Co., et al	In the United States District Court for the District of New Jersey	Civil Action No. 91-2907	8/8/2000	Deposition	Asbestos buildings
Port Authority of New York and New Jersey et al v. Affiliated FM Insurance Co., et al	In the United States District Court for the District of New Jersey	Civil Action No. 91-2907	8/7/2000	Deposition	Asbestos buildings

Deposition and Trial Testimony of Richard Lee

Case Name	Court	Case Number	Testimony Date	Testimony	Case type
Rhonda K. Lane vs. Flexitallic Gasket Company and Crane Packing	In the Court of Common Pleas First Judicial District of Pennsylvania Trial Division	No. 1847	7/28/2000	Trial	Asbestos PI -- Gaskets
Kerner vs. Rancho Cielo Associates	Orange County Superior Court	Lead Case No. 772079 - consolidated with various other case numbers	7/21/2000	Deposition	Concrete failure
Kerner vs. Rancho Cielo Associates	Orange County Superior Court	Lead Case No. 772079 - consolidated with various other case numbers	7/20/2000	Deposition	Concrete failure
Kerner vs. Rancho Cielo Associates	Orange County Superior Court	Lead Case No. 772079 - consolidated with various other case numbers	6/20/2000	Deposition	Concrete failure
Kerner vs. Rancho Cielo Associates	Orange County Superior Court	Lead Case No. 772079 - consolidated with various other case numbers	6/19/2000	Deposition	Concrete failure
Allstate Insurance Company adv. Walter and Barbara Morosco - Walter A. Morosco and Barbara Morosco vs. Allstate Insurance Company et al	United States District Court Central District of California	95-7416 MRP (CTx)	6/9/2000	Trial	Asbestos buildings

Deposition and Trial Testimony of Richard Lee

Case Name	Court	Case Number	Testimony Date	Testimony	Case type
Siman, et al. v. The Fieldstone Company (Cantobrio)	Orange County Superior Court	Case No. 778957	5/22/2000	Trial	Concrete failure
Siman, et al. v. The Fieldstone Company (Cantobrio)	Orange County Superior Court	Case No. 778957	5/18/2000	Trial	Concrete failure
Brayton Group 172 / Brayton Group 178 / Brayton Group 183 vs. Asbestos Defendants (Paul Duran) / (Jack Reed) - Flexitallic Gasket Testing	In The Superior Court of The State of California in and for the City and County of San Francisco	No. 307521	5/8/2000	Deposition Telephone	Asbestos PI -- Gaskets
Jack and Mary Reed vs. Flexitallic, Inc. (Flexitallic Gasket Testing)	Superior Court of California City and County of San Francisco	309045	5/5/2000	Deposition Telephone	Asbestos PI -- Gaskets
Titmus Optical v. William T. Curd, Jr. et al. (ReUse Technologies)	In the Circuit Court of the City of Richmond John Marshall Courts Building	File No.: LE-2744	5/4/2000	Deposition	Structural Fill
Flexitallic Gasket Testing (James Leroy Amason Case vs. Allied Signal, Inc.)	In the Circuit Court for the Tenth Judicial Circuit - Jefferson County, Alabama	No. CV98-04124-AEH	4/19/2000	Deposition	Asbestos PI -- Gaskets

Deposition and Trial Testimony of Richard Lee

Case Name	Court	Case Number	Testimony Date	Testimony	Case type
Mark Lewis and Shirley Hackett vs. Raybestos-Manhattan, Inc., et al. (Flexitallic Gasket Testing)	In the Superior Court of the State of California in and for the City and County of San Francisco	No. 306744	3/20/2000	Deposition Telephone	Asbestos PI -- Gaskets
Earlon Joseph Nunez, et ux v. Owens Corning Corporation et al (Flexitallic Gasket Testing)	In The Civil District Court of the Fifteenth Judicial District in and For the Parish of Vermilion State of Louisiana	Civil Docket No. 70432	3/1/2000	Trial	Asbestos PI -- Gaskets
Vern Parent v. Raybestos - Manhattan, Inc., et al. (Flexitallic Gasket Testing)	In the Superior Court of the State of California in and for the County of Alameda	No. 305994	2/28/2000	Deposition Telephone	Asbestos PI -- Gaskets
Cecil Martin & Paul Borre vs. Asbestos Defendants (BHC) - Flexitallic Gasket Testing	In the Superior Court of the State of California in and for the City and County of San Francisco	No. 305398 No. 302857	2/16/2000	Deposition	Asbestos PI -- Gaskets
Vern Parent v. Raybestos - Manhattan, Inc., et al. (Flexitallic Gasket Testing)	In the Superior Court of the State of California in and for the County of Alameda	No. 305994	2/16/2000	Deposition Telephone	Asbestos PI -- Gaskets
Robert V. Rugani and Louis Rugani v. A.P. Green Industries, Inc. et al - Flexitallic Gasket Testing	Superior Court in the State of California for the County of San Francisco	No. 302355	2/7/2000	Deposition Telephone	Asbestos PI -- Gaskets

Deposition and Trial Testimony of Richard Lee

Case Name	Court	Case Number	Testimony Date	Testimony	Case type
BHC # 166 / Brayton Group 166 v. Asbestos Defendants (BHC) - Flexitallic Gasket Testing	In the Superior Court of the State of California in and for the County of San Francisco	No. 972095	2/7/2000	Deposition Telephone	Asbestos PI -- Gaskets
Hanson, Lynn v. USG	Circuit Court of the State of Oregon for the County of Multnomah	9907-07883	2/3/2000	Deposition Telephone	Asbestos PI -- Product ID

RJLG

Expert Report
Limitations of Dust Sampling Methodology

Report Date: October 17, 2005

Prepared for:
W.R. Grace & Company
Columbia, MD 21044

Project No. LSH505344

Expert Report
Limitations of Dust Sampling Methodology

Qualifications

Dr. Richard J. Lee obtained a Bachelor of Science degree in physics from the University of North Dakota in 1966 and a Ph.D. in theoretical solid state physics from Colorado State University in 1970. He then went to Purdue University as an Assistant Professor in physics where he taught courses on the principles of optical microscopy. He received tenure at Purdue in less than two years.

In 1973, Dr. Lee went to work for United States Steel (US Steel), first as a research scientist and thereafter, as director of their physics and electron microscopy department in the Technical Center. He remained at the US Steel Research Center until 1985. While at US Steel, he analyzed a wide range of materials and was employed by NASA to analyze moon rocks brought back by the Apollo missions.

During his tenure at US Steel Research, Dr. Lee was responsible for developing the first techniques for quantitatively identifying amphibole asbestos fibers and cleavage fragments by a combination of transmission electron microscopy and energy dispersive X-ray analysis. He participated in the original ASTM committee that developed and evaluated the first TEM methods for preparing samples of air, bulk and water for the determination of asbestos content. Dr. Lee was the first scientist to develop methods for distinguishing asbestos amphiboles from cleavage fragments using transmission and scanning electron microscopy.

Since 1985, Dr. Lee has been President of a company now known as RJ Lee Group, Inc., ("RJ Lee Group") which has its principal office in Monroeville, Pennsylvania, and laboratories in San Leandro, California; and Manassas, Virginia. RJ Lee Group provides research, analytical and consulting services relating to materials characterization. Materials characterization of bulk building materials, also referred to as "constituent analysis", involves analyzing a sample of material using various techniques to identify and quantify the components of that material.

Dr. Lee has a long history of scientific consulting and service for government agencies, including the United States Environmental Protection Agency (EPA). RJ Lee Group's laboratory serves as a quality assurance and referee laboratory on a number of EPA programs. RJ Lee Group's laboratory performed the analyses for the EPA's major study on airborne levels of asbestos in public buildings. Dr. Lee has participated in the development by the EPA of analytical methods and procedures for asbestos analyses. The

EPA requested that he personally participate in several projects, including the drafting of the portions of the Agency's AHERA regulations governing air sample analysis after abatement. Dr. Lee was an invited member of the Health Effects Institute - Asbestos Research literature review panel, sponsored by the EPA. RJ Lee Group also has performed analyses for the United States Navy, the United States Army and the United States General Services Administration. Dr. Lee developed a program to determine the cause of failure in components of the guidance system in the Trident missile for the Department of the Navy.

RJ Lee Group's laboratory has also performed microscopic analyses for the State of California Air Resources Board when that agency performed testing of the air in major cities in the State of California to determine the presence of asbestos.

Dr. Lee is now engaged in and specializes in materials characterization, which is the science that uses a variety of analytical techniques to determine the identity and amount of each component of a material. He has performed materials characterization analyses on many samples of vermiculite produced from different sources for over 15 years. He is familiar with all methods of microscopy that are commonly used in characterizing asbestos or identifying and quantifying asbestos, including optical microscopy, scanning electron microscopy and transmission electron microscopy. He is also familiar with all known methodologies, from air sampling to dust sampling, with respect to asbestos. Dr. Lee is a member of the ASTM committee that has developed the dust sampling methods now in question. He has worked extensively with, and is an expert in, analytical techniques including light and electron microscopy, materials characterization, asbestos air, bulk, and dust samples, and methods of evaluation. He has also served as an expert witness in litigation involving asbestos in buildings and has testified in state and federal courts.

Dr. Lee is familiar with airborne levels of asbestos fibers both in buildings and in outdoor air, the sources of asbestos in the outside or ambient air, scientific knowledge and techniques regarding the measurement of levels of asbestos in the air, the development and use of the technology to measure both airborne levels of fibers and levels in materials samples, and the standards and methods used for air sampling. He has been involved in analyzing and producing bodies of air sampling data for EPA and other governmental and private entities including analysis of samples taken in an ongoing nationwide study of airborne levels in buildings and his analysis of air samples taken in an EPA-sponsored study in Texas.

He is also familiar with the history of standards governing asbestos including the current standards, regulatory positions and philosophies,

different types of asbestos fibers, asbestos fiber levels as reported in the literature, as well as his own work concerning buildings with asbestos-containing materials.

Dr. Lee's fee for consulting, depositions, and trial appearances is $350 per hour.

Summary of Opinions

Dust sampling and analyses, as applied to dust and debris from in-place building materials, are not reproducible.

The reported asbestos concentrations for dust samples do not accurately represent the concentration of asbestos in surface dust and debris. The use of the "indirect" sample preparation method for analyzing surface dust modifies the collected material by shaking and sonicating the sample in an acidic solution. Data derived from "indirect" preparation have very large variability; the number of asbestos structures is exaggerated due to the sample preparation procedure.

Because of the "indirect" sample preparation procedures used for dust analyses, the dust methods are particularly unsuited for analyzing debris from a cementitious fireproofing or acoustical plaster product. The "indirect" method dissolves the matrix materials binding the asbestos fibers together, generating or liberating individual, free asbestos fibers that were not present as such in the surface dust.

Dust sampling and analyses are not recognized within the scientific or regulatory communities as a means of assessing or predicting inhalation exposure and have not been incorporated into any regulatory standards for such use.

Dust sampling and analyses provide no information on past or future concentrations of respirable asbestos fibers that are or may be in the air.

Physical Characteristics, Composition and Properties of Fireproofing Acoustical Plaster Materials

Fireproofing materials are applied to the surface of decks, beams and other structural members of buildings. Sprayed on fireproofing containing asbestos was applied by either wet or dry methods beginning in the late 1950's through the early 1970's. In the dry method, the materials are blown through a tube and mixed with water at the point of application. In the wet process, the materials are mixed with water, then pumped through a tube and sprayed on structural steel. In both cases, the action of a water-

activated binder causes them to stick to the surface and when dried or set, form a resilient cohesive coating.

The primary requirement of fireproofing materials applied to steel structures is that they both prevent the spread of fire and protect the steel structure against deformation, at least for sufficient time to permit safe evacuation of building occupants. Thus, they must be fire resistant: they must provide a mechanism for the safe dissipation of heat away from the steel members which they protect and they must retain their integrity, both long term over the life of the building and short term when subjected to a fire episode.

Acoustical plaster materials were applied to ceilings and walls of buildings. The materials were sprayed-on or troweled on depending on the particular use. As applied, water would cause a chemical bonding to take place in the product encapsulating any fibers in the product. These materials (with asbestos) were in use from the late 1950's through the early 1970's.

The general composition of the acoustical plaster products was a binder (cement or plaster of paris) combined with a light-weight aggregate (vermiculite or perlite), asbestos (chrysotile), and sometimes some clay (montmorillonite or bentonite). Other additives were used to improve setting, increase the whiteness of the product, or reduce bacterial growth in the product.

The principal function of acoustical plasters is to reduce ambient levels of sound in a room by partial adsorption of the sound and by selective reflection of the sound. The products, while providing an architecturally acceptable surface finish, adhere to building materials such as ceiling decking, metal duct work, and other wallboard or plaster finishes.

Some of the binder materials also undergo a chemical reaction with water, precipitating onto and encapsulating the remaining particles; these reacted materials are known as cementitious.

The American Society for Testing and Materials (ASTM), an organization which defines terms, standards and testing methods for materials, defines a cementitious material as "A material that, when mixed with water, with or without aggregate, provides the plasticity and the cohesive and adhesive properties necessary for placement and the formation of a rigid mass". Implicit in this definition is the ability of the material to adhere to the structure to which it is applied not only during application but also after setting up in place. The constituents of these WR Grace fireproofing and acoustical products are such that the material meets ASTM's definition of cementitious.

Asbestos-Containing Fireproofing and Acoustical Plaster Materials do not Spontaneously Degrade or Shed Individual, Free Fibers

The constituents of the cementitious fireproofing materials and acoustical plasters at issue are stable and do not spontaneously degrade or shed individual fibers even when physically or chemically attacked.

Constituents which were used in the WR Grace products, in addition to minor quantities of asbestos, were plaster, gypsum and vermiculite. Thus, the materials used in the formulation of the products at issue are, after setting, chemically inert with respect to normal building conditions. The bonding action between the cementitious matrix and its fiber reinforcement results in products which are dimensionally stable and possess excellent cohesion by virtue of the reinforcing action of the asbestos fibers in their formulations. They do not degrade or release components spontaneously. They do not spontaneously delaminate or lose adherence if they are correctly applied and if the building is properly maintained.

When applied and maintained appropriately, these products will withstand degradation due to impact, bending, compression and air erosion. The materials of interest in this case are inert, non-reactive materials. They have been consolidated into a system which in and of itself will not degrade or deteriorate. Unless improperly applied, or subjected to adverse environmental conditions, these materials will maintain their integrity.

The components of these materials are found in nature giving rise to their intrinsic stability. The asbestos is encapsulated or otherwise tightly enmeshed by the primary constituents and itself becomes an interlocking member of the system. Even when mechanically disturbed or intruded upon the system will fracture in such a manner as to release debris particles, not individual respirable asbestos fibers.

These materials have been subjected to a variety of air erosion tests[1,2,3] which demonstrated, within the state-of-the-art, that they did not release individual asbestos fibers. In addition, RJ Lee Group has subjected the

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1 Boyle Engineering Laboratory (1965). Report of Air Velocity Surface Erosion Test on Firecode Plaster, Test performed for United States Gypsum Company, September 1965.

2 Boyle Engineering Laboratory (1967). Report of Effect of High Velocity Air Upon the Surface of Mono-Kote Material Having a Dry Bulk Density of 16.85 lbs. per cu. ft., performed for Zonolite Division, W.R. Grace & Company, January 16-20, 1967.

3 D. Keyes, W. Ewing, and S. Hays (1990). "Recent Research on Fiber Release from ACM and Re-entrainment of Asbestos Dust", Session 20, presented at the National Asbestos Council Seventh Annual Asbestos Abatement Conference and Exposition, San Antonio, TX.

fireproofing material to extensive pulverization tests[4] demonstrating that no significant airborne fiber levels were generated by the action.

Dust Sampling and Analysis

Dust sampling and analysis is a methodology by which dust is collected from a surface and the content of asbestos evaluated. The dust may be collected by a technique known as a microvacuum or a microvac, in which a partial vacuum is created at a membrane filter surface and dust particles pulled from a surface are deposited either on the filter surface or in the cassette holder. A variety of other methodologies are also employed including application of a sticky surface (adhesive lift) sample to the dust to collect particles, or wiping a damp cloth or filter (wipe sample) over the surface. The analysis of these samples for asbestos content can be performed by optical or electron microscopy.

Sample preparation of surface dust samples is accomplished utilizing an "indirect" methodology. In the indirect analysis particles are removed from collection media, suspended in acid water, and subjected to mechanical agitation (currently employing ultrasonic treatment). The sonication time varies from three to fifteen minutes. A portion of the suspended material is then deposited onto a membrane filter for microscopic analysis.

The development of the dust procedures began in the 1980's as an outgrowth of AHERA building inspections. During these inspections, dust was observed on the top of ceiling tiles, on top of bookshelves, or other areas which were not routinely cleaned. It was theorized that this dust may contain asbestos, but there were no published methods for the collection and analysis of this matrix. RJ Lee Group participated in the formulation and development of these dust sampling analytical methods.

EPA Dust Protocol

In 1989, the U.S. Environmental Protection Agency (EPA) hosted a meeting in Cincinnati to discuss dust sampling and analysis. The outgrowth of this meeting was a draft EPA protocol[5] which was designed to improve "the degree of precision for this analysis". However, as noted by the method, the accuracy of the method was in question as "no single type of microscope can accurately cover the entire range of fiber sizes without relatively over- or under-estimating asbestos concentrations".

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[4] RJ Lee Group, Inc. (1995). Videotape: The Measurement of Fiber Release During Pulverization of Friable Fireproofing, September 29, 1995.

[5] P. J. Clark and K. Brackett (1990). "Draft Test Method for Sampling and Analysis of Dust for Asbestos Structures by Transmission Electron Microscopy", U.S. Environmental Protection Agency, Cincinnati, OH.

Though developed as a standard procedure, the dust procedure was never meant to be used alone. As noted in the draft EPA procedure: "This technique will augment visual inspection and air monitoring". Thus, it provides supplementary information to the primary building survey techniques - visual inspection, air monitoring and bulk sample analyses. The method was also designed to collect all dust on a surface, even extremely adherent dust where "a small spatula may have to be used to dislodge the particulates before microvacuuming the surface".

More significantly, the EPA acknowledged that the sample preparation procedure for the microvacuum method increases the number of counted asbestos fibers: "As this method involves the use of sonication to disperse the fibers in the dust sample prior to dilution and filtration, it will increase the number of small fibers counted in relation to what may have actually been found on the surface." The manner in which "indirect" preparation alters the number and character of asbestos structures in the dust is discussed in detail below.

ASTM Dust Procedures

The draft EPA procedure was submitted to the ASTM asbestos committee (currently D22.07) for consideration and development into a standardized method. The development by ASTM of standardized methods is the result of a consensus procedure. The methods do not require a unanimous vote to be approved, only a super-majority affirmative vote of the committee members. Disagreements and negative votes on balloted items are discussed at biannual meetings. Negative ballots must be considered, but can be deemed "non-persuasive" by a super-majority of the attending committee members. Thus, a method having been approved does not imply unanimous agreement - there may be technical issues unresolved but acceptable to a majority of committee members.

Balloting on the surface dust method began in early 1990 with a final consensus version not completed until 1995. At that time, the microvacuum method, ASTM D-5755-95[6], was issued. That method involves collection of samples by a microvacuum, indirect sample preparation, and results reported as the number of asbestos structures per square centimeter of sampled surface. During its five year development, significant changes were made to the method, both qualitative and quantitative, following vigorous committee discussions. In addition, a parallel method (ASTM D-5756-95)

[6] The published ASTM dust methods can be found in volume 11.03 of the *Annual Book of ASTM Standards*, American Society for Testing and Materials, Conshohocken, PA.

that measures the mass of asbestos in surface dust was started in 1993 and moved through balloting in tandem with the structure count method.

The ASTM methods include directives and guidance that delineate the usefulness and limitations of the method. The method is limited to the "general testing of non-airborne dust samples for asbestos". As noted, the "collection efficiency of this technique [microvaccum] is unknown and will vary among substrates". Like the draft EPA protocol, the ASTM method also acknowledges that the indirect sample preparation procedure "may alter the physical form of the mineral fibers".

One of the fundamental changes made to the draft EPA method when converting it into an ASTM method was to modify the definition of "dust". The draft EPA defined dust particles as 20 µm and smaller. In the ASTM methods, however, a much larger sized particle, 1 mm and smaller, was embodied in the definition. Because the sample collection nozzle is passed over a surface on which a range of particle sizes may occur, any particle that can fit into the nozzle will be collected, not just particles that may be respirable in size. Therefore, the definition of dust was increased to the larger size.

Considerable variation has taken place and continues to take place in the application of the microvacuum sampling and analysis methodology for settled dust. Thus, no scientifically viable conclusion may be drawn from dust samples collected in this manner.

Furthermore, despite the efforts of ASTM to develop standard methods, sample collection is far from standardized. For example, some practitioners apply pressure on the surface sampled in order to dislodge dust from it. Such pressure is not called for in the ASTM standards because it is difficult if not impossible to accurately apply this pressure. Because the pressure will vary and have unpredictable results on the amount of material collected, data from one area cannot be reliably compared with data from other locations.

The ASTM methods specifically state that "no relationship has been established between asbestos-containing dust as measured by [these methods] and potential human exposure to airborne asbestos".

Following completion of the two microvacuum sampling methods, a third method was developed by the ASTM committee. Currently designated as D 6480-99, this method uses a wet wipe (such as a clean room wipe) to collect the surface dust. Unlike the microvaccuum technique which attempts to limit the collected particles to those smaller than 1 mm, the wipe procedure collects all particles deposited within a designated sampling area. The first

draft of the method was balloted in 1996; final balloting and passage of the method occurred in 1999.

Dust methods do not measure the dust as it occurs on the surface

The sample preparation methods used in measuring the asbestos content of dust collected by the ASTM methods results in distortion of both the sizes and number of asbestos structures in the sample. In particular, ultrasonic treatment, especially in combination with the use of acidified water, so disrupts the asbestos particles present in asbestos-containing dusts as to nullify any attempt at estimating their number concentration.

The ability of ultrasonic energy to disrupt asbestos particles and split them into finer particles has not only been known for many years, but was in fact a basis for mineral beneficiation of chrysotile ores in the early 1960's.[7] Sample preparation procedures for transmission electron microscopic examination in the late 1960s and early 1970s was based on the use of ultrasonics. Spurny[8] reported on the effect of ultrasonic treatment of asbestos fibers, reporting on changes to the size and aspect ratio of fibers. In studies of asbestos in water, Chatfield[9] quantified the breakup of asbestos by ultrasonics and showed how it increased with time and input power. Chesson[10] conducted a statistical study of comparisons of direct and indirect preparation of air samples and showed that in all cases the number of fibers observed in indirect preparations were higher than in direct preparations. Burdett[11] compared direct and indirect sample preparation and concluded that the indirect method modified the fiber count by breaking up agglomerates and that the direct preparation procedure was useful for exposure assessment.

Sahle[12] and Kauffer[13] similarly showed that indirect sample preparation induces very high apparent fiber concentrations due to the action of

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[7] E. Martinez (1963). "Effect of Ultrasonic Energy on Chrysotile Asbestos", Transactions of AIME, p. 388 - 390.

[8] K. R. Spurny, W. Stöber, H. Opiela, and G. Weiss (1980). "On the problem of milling and ultrasonic treatment of asbestos and glass fibers in biological and analytical applications", *American Industrial Hygiene Association Journal*, 41, p 198-203.

[9] E. J. Chatfield, R. W. Glass, and M. C. Dillon (1978). "Preparation of Water Samples for Asbestos Fiber Counting by Electron Microscopy," U.S. Environmental Protection Agency (EPA), EPA-600/4-78-011.

[10] J. Chesson and J. Hatfield (1990). "Comparison of Airborne Asbestos Levels Determined by Transmission Electron Microscopy (TEM) Using Direct and Indirect Transfer Techniques", U.S. Environmental Protection Agency (EPA), EPA 560/5-89-004.

[11] G. Burdett (1985). "Inter-laboratory Comparison of the U.S. Environmental Protection Agency School Samples by the UK Health and Safety Executive", report no. IR/DI/86/03.

[12] W. Sahle and I. Laszlo (1996). "Airborne Inorganic Fibre Level Monitoring By Transmission Electron Microscope (TEM): Comparison Of Direct And Indirect Sample Transfer Methods," *Annals of Occupational Hygiene*, 40, p. 29-44.

ultrasonic treatment, which results in the breakdown of fibers in both length and diameter.

Our own work has shown that ultrasonic treatment results in the breakup of fireproofing debris particles, as well as the break-up of asbestos fibers of the size present in asbestos-containing fireproofing. We have demonstrated[14] that this breakup occurs early in the ultrasonic process. Through the use of ultra slow motion videography, we have demonstrated that this breakup is often explosive and instantaneous when the ultrasonic power is applied, with massive disruption of debris particles from an asbestos-containing fireproofing or of Grade 7M asbestos particles occurring within three seconds of application of the ultrasonic power. We have performed an inter-laboratory comparison of the effect of indirect preparation on single particles of fireproofing and asbestos bundles.[15] The results demonstrate that a single non-respirable particle of fireproofing products, when subjected to the sample preparation procedures of the indirect microvac protocol, produces the equivalent of hundreds of millions of fibers in the final result.

Lee[16] points out that the dilutions used by various laboratories also differ significantly and contribute to large variability between laboratories. Variations in dilution factors are thus likely to account for more variability than does location of the sample.

Because the matrices of the cementitious fireproofing and plaster materials are soluble in acid, the dust method's use of acidified aqueous suspension results in the dissolution of these matrices and consequential release of asbestos fiber bundles that would otherwise remain encapsulated in the fireproofing. Once released, these fiber bundles are more susceptible to ultrasonic disruption than they would be when held in their cementitious matrix. Consequently, the combined use of ultrasonic treatment and acidified aqueous suspensions synergistically leads to enhanced fiber breakup and thus to artificially increased concentrations of fibers in the dust. As a result, the fiber bundles observable to the naked eye become subdivided into numerous smaller fibers.

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13 E. Kauffer, M.A. Billon-Galland, J.C. Vigneron, S. Veissiere and P. Brochard (1996). "Effect of Preparation Methods on the Assessment of Airborne Concentrations of Asbestos Fibres by Transmission Electron Microscopy", *Annals of Occupational Hygiene*, 40, p. 321-330

14 RJ Lee Group (1993). Videotape: Ultrasonic Breakup of Chrysotile Grade 7M and Fireproofing", March 2, 1993.

15 R. J. Lee, T. Dagenhart, G. Dunmyre, I. Stewart, and D. Van Orden (1995). "Effect of Indirect Sample Preparation Procedures on the Apparent Concentration of Asbestos in Settled Dusts", *Environmental Science & Technology*, 29, p 1728 - 1736.

16 R. J. Lee, D. Van Orden, G. Dunmyre, and I. Stewart (1996). "Interlaboratory Evaluation of the Breakup of Asbestos-Containing Dust Particles by Ultrasonic Agitation", *Environmental Science & Technology*, 30, p. 3010 - 3015.

Every author reporting on comparison of direct and indirect preparation recognized that the indirect preparation method modifies the sample and increases the fiber count.[8,9,10,11,12,13,14,15,16] Those that have conducted detailed experiments conclude that the increase results from the break-up or dissolution of particles containing asbestos and from modification of the fiber size distribution, i.e., breakage of longer fibers into shorter fibers and bundles of fibers into individual fibers.[15,16,17] As a result the numerical concentration of asbestos reported by the ASTM dust procedures has no relationship to the asbestos structures as they occur in the dust on the surface.

Dement, a former Director of the National Institute for Environmental Health Sciences, succinctly summarizes the issue with indirect preparation when he states[18]: "The use of indirect sample transfer for transmission electron microscopy (TEM) of asbestos has been shown to break up the airborne fibers into smaller units. Depending upon the treatment, the observed concentration of fibers and their size distribution change drastically. There is no biological justification for such a violent treatment, and the measured entity is not a biologically justifiable measured quantity. Therefore, the use of indirect sample transfer method for asbestos sampling should be discouraged and the more gentle direct transfer method should be used."

In summary, the indirect ASTM dust procedures modify the sample making it impossible to evaluate whether asbestos in surface dust is individual, free and respirable fibers or particles of debris that have been broken up in the process.

Surface dust in typical buildings with ACM does not readily become airborne

Surface dust does not readily become airborne. The particle size, cohesion and moisture content affect the ability of surface dust to be resuspended. High air velocities, in excess of 100 mph, were necessary to liberate asbestos fibers from a surface. Guillaman[19] found increased levels of fibrous particulate during periods of high activity in schools, but no increase in

[17] E. J. Chatfield (1999). "Correlated Measurements of Airborne Asbestos-Containing Particles and Surface Dust", *Advances in Environmental Measurement Methods for Asbestos*, ASTM publication STP 1342.
[18] J. Dement (1990). "Overview: Workshop on Fiber Toxicology Research Needs", *Environmental Health Perspectives*, 88, p. 261- 268.
[19] M. P. Guillaman and P. Madelaine (1989). "Asbestos in Buildings: The Difficulties of a Reliable Exposure Assessment", *Aerosol Science and Technology*, 11, p. 221 - 243.

asbestos concentrations. Guth[20] estimated the contribution of surface dust to airborne concentrations at less than 1% of the available particles.

A study by the Missouri Department of Health[21], cited by OSHA in their 1994 rulemaking, found that a variety of custodial activities including dry sweeping of asbestos-containing dust and debris produced airborne concentrations well below the OSHA limit. Our own analysis of air samples related to clean-up of asbestos-containing dust and debris following an earthquake found virtually all samples to be below the PEL[22].

Millette and Heffernan[23] reported concentrations well below the PEL when dry sweeping asbestos dust produced during a simulated maintenance activity.

Dust sampling is not recognized as a means of exposure assessment

Dust sampling and analysis, in contrast to air sampling, is not recognized within the scientific, regulatory or industrial hygiene communities as a means of assessing or predicting exposures. It has not been incorporated into any regulatory standard, nor is there any literature correlating the results of microvacuum dust sampling to airborne concentrations of asbestos.

Mr. Michael Beard, formerly with EPA's Quality Assurance Branch in Raleigh, NC, was a frequent presenter at technical meetings, symposia and courses in the early 1990's. In courses on settled dust analysis, sponsored by the Georgia Institute of Technology, by the Environmental Information Association and by ASTM, Mr. Beard repeatedly stressed that EPA has neither an official method for the analysis of asbestos in settled dust nor an official policy for its use.

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[20] J. H. Guth (1990). "Interpretation og Surface Asbestos Contamination Data: The Closed Finite System Model, Update #1", presented at the NAC Fall Technical Conference, Phoenix, AZ.
[21] A. R. Wickman, D. W. Roberts, and T. L. Hooper. "Exposure of Custodial Employees to Airborne Asbestos", Missouri Dept. of Health Report to the EPA, EPA Project J1007468-01-0.
[22] D. Van Orden, R. Lee, K. Bishop, D. Kahane, and R. Morse (1994). "Evaluation of Ambient Asbestos Concentrations in Buildings Following the Loma Prieta Earthquake", *Regulatory Toxicology and Pharmacology*, 21, p. 117 - 121.
[23] MVA Inc. and P. Heffernan (1993). *Airborne Asbestos Levels During Simulated Maintenance Operation of Inspecting the Area above the Tile Ceiling in the Cafeteria of the Saltonstall Building in Boston*, Report of Results, MVA0376, prepared for the Commonwealth of Massachusetts, March 19, 1993.

There is no correlation between dust sample results and airborne levels of asbestos

Results of microvac dust sampling bear no correlation or relationship to either past or potential airborne levels[24] in buildings. In fact, the ASTM dust method itself recognizes this limitation. The ASTM D5755 method states (section 5.1.2): "At present, no relationship has been established between asbestos-containing dust as measured by this test method and potential human exposure to airborne asbestos."

An extensive data set of air and dust samples collected in residential properties was evaluated to determine whether any correlation exists between airborne concentrations of asbestos and asbestos concentrations measured in settled dust. These samples were collected in buildings that were allegedly damaged during an earthquake in southern California. Interior airborne asbestos concentrations were higher than outdoor concentrations; indoor airborne levels did not correlate with asbestos concentrations in the dust as measured by the indirect ASTM TEM methods. The presence of asbestos in the surface dust was shown to be independent of the presence of asbestos in bulk samples collected from the residences. The presence of airborne asbestos was also shown to be independent of the presence of asbestos in surface dust. Thus, observing asbestos in a dust sample does not imply that asbestos will be found in an air sample nor does it imply that asbestos will be found at some predictable concentration.

Chatfield[25] has produced supporting documentation that shows the airborne particles from a controlled abrading of ACM are not correlated with dust that fell to the surface. He showed that the individual chrysotile fibers observed in the surface dust, when indirectly prepared in accordance with ASTM D5755, "could not have been present in the original dust and debris which settled" during the tests and that the "numbers, sizes and characteristics of the chrysotile structures ... were therefore not representative of the particles as they existed on the original surface".

Fowler and Chatfield[26] conclude that dust sampling has little value for predicting potential airborne concentrations especially if indirect

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[24] R. J. Lee, D. Van Orden, and I. Stewart (1999). "Dust and Airborne Concentrations – Is There a Correlation?", *Advances in Environmental Measurement Methods for Asbestos*, ASTM publication STP 1342.
[25] E. J. Chatfield (1999). "Correlated Measurements of Airborne Asbestos-Containing Particles and Surface Dust", *Advances in Environmental Measurement Methods for Asbestos*, ASTM publication STP 1342.
[26] D. P. Fowler, and E. J. Chatfield (1997). "Surface Sampling for Asbestos Risk Assessment," *Annals of Occupational Hygiene*, 41, Supplement 1. p 279-286.

preparation is used. Sansone[27] warns that interpretation of dust sample analysis and resuspension data is subject to many variables.

The EPA also notes that asbestos in dust and airborne asbestos are not related:[28] "At present no firm conclusions can be drawn regarding potential exposure hazards from asbestos contaminated surface dust and no limits have been set to define a level requiring abatement or cleaning of an area."

Richard J. Lee
President

[27] E. B. Sansone (1987). "Redispersion of Indoor Surface Contamination and Its Implications", *Treatise on Clear Surface Technology*, Ed. K. L. Mittal, 1, p 261-290.

[28] P. J. Clark and K. Brackett (1990). "Draft Test Method for Sampling and Analysis of Dust for Asbestos Structures by Transmission Electron Microscopy", U.S. Environmental Protection Agency, Cincinnati, OH. The statement is in the Foreword to the method.

RJLG

Rebuttal Expert Report:
Limitation of Dust Sampling Methodology

Project LSH505344

Report Date: January 19, 2006

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Rebuttal Expert Report

1.0 Introduction

Two expert reports were submitted by plaintiff's experts related to surface dust sampling. These reports (one by Dr. W. Longo and another by W. Ewing) purport to show that dust sampling has a long and established history, is a scientifically reliable method, and is useful in evaluating health risks. Of these three points, the issue of whether the method is scientifically reliable is the primary issue. Health risks can only be properly interpreted when the risk data are developed using reliable analytical procedures. The microvacuum method is flawed, in large part, because it modifies the sampled particles, altering the manner in which the particles were found on the surface and removing asbestos fibers from any matrix materials in which they were bound.

2.0 Scientific Reliability of the Method

The primary question to be answered is whether the method is scientifically reliable. Longo suggests the method has been favorably peer reviewed and has been tested to show an acceptable degree of reproducibility. Contrary to these opinions, the method has been unfavorably peer reviewed and has been shown to have a built-in, uncontrolled bias and is inherently non-reproducible.

The basic tenets of the microvacuum method have been reviewed by Lee[1,2], Kauffer[3], Sahle[4], Chatfield, and others. Each of these reviews has shown the method to be an unreliable procedure for evaluating the number concentration of asbestos fibers in surface dusts. The reviews referenced by Longo (references 1, 3-7, and 9-11 on page 12 of Longo's report) were

[1] Lee, R. J.; Dagenhart, T. V; Dunmyre, G. R.; Stewart, I. M; and Van Orden, D. R. (1995). "Effect of Indirect Sample Preparation Procedures on the Apparent Concentration of Asbestos in Settled Dusts", *Environmental Science & Technology*, 29, p. 1728 - 1736.

[2] Lee, R. J.; Van Orden, D. R.; Dunmyre, G. R.; and Stewart I. M. (1996). "Interlaboratory Evaluation of the Breakup of Asbestos-Containing Dust Particles by Ultrasonic Agitation", *Environmental Science & Technology*, 30, p. 3010 - 3015.

[3] Kauffer, E., Billon-Galland, M. A., Vigneron, J. C., Veissiere, S., and Brochard, P. (1996). "The Effect of Preparation Methods on the Assessment of Airborne Concentration of Asbestos Fibers by Transmission Electron Microscopy". *Annals of Occupational Hygiene*, 40, p. 321 - 330.

[4] Sahle, W., and Lazlo, I. (1996). "Airborne Inorganic Fibre Level Monitoring by Transmission Electron Microscopy (TEM): Comparison of Direct and Indirect Sample Transfer Methods". *Annals of Occupational Hygiene*, 40, p. 29 - 44.

conducted either by Longo's laboratory or by experts routinely retained by plaintiffs in property damage litigation.

The issues related to the microvacuum technique are illustrated by testing conducted on simulated building dusts. In each of these tests, the surface dust deposition was controlled so that a uniform layer of dust was generated for later sampling and analysis.

Crankshaw[5] created "dust" using calcium carbonate and chrysotile asbestos, mixed those materials in known concentrations, and distributed them in a dust chamber for later microvacuum sampling and analysis. Even with a uniform deposition of dust, Crankshaw's data show there is a 75% variability[6] in the asbestos structure counts.

Lee (reference 2) also tested a simulated building dust by mixing a reference clay/quartz material with approximately 1 kg of building dust collected from a building with asbestos-containing sprayed-on fireproofing. The mixed material was blown around a room in which various surfaces (ceiling tiles, wood, and carpet) had been placed. Samples collected from the ceiling tile and analyzed by a single laboratory show up to 57% variability of the asbestos structure counts.

Therefore, the data show that even with uniformly deposited "dusts", the sampling methodology employed by Claimants' experts yields substantial differences in analytical results (57 to 75% variability).

What components of the methodology produce such scientifically unacceptable results? The dust sampling techniques can be divided into sample collection, sample preparation, and sample analysis. Of these three parts, sample collection and sample preparation generate bias and non-reproducibility.

2.1 Sample Collection

A handheld sampling pump is used to vacuum the surface dust from a defined area into a cassette. As noted in the method, the sample area is "vacuumed until there is no visible dust or particulates matter remaining". However, the sampling technician is to "[a]void scraping or abrading the

[5] Crankshaw, O., Perkins, R. L., and Beard, M. E. (1996). "Quantitative Evaluation of the Relative Effectiveness of Various Methods for the Analysis of Asbestos in Settled Dust", *EIA Technical Journal*, 4, p. 6 – 12.

[6] Order-of-magnitude confidence intervals (intervals that range from 0 up to twice the reported value) on the average value of side-by-side samples require the sample variability to be no more than 11% for paired samples and no more than 40% when three samples are collected. For tighter (smaller) confidence intervals, lower levels of variability are required. ASTM is currently writing a guidance document for surface dusts (WK7719) where a 7% variability is used for example calculations.

surface being sampled". Particles larger than 1 mm are not to be collected. (Step 8.7 of D5755).

Microvacuuming is not performed consistently between different investigators, leading to differences in asbestos structure counts. In a sampling event conducted by Ewing and Van Orden at several Illinois universities, a particular window ledge was selected by Ewing for one sample collection event. The window ledge was on an inside window where Coca-Cola had been spilled (the can was on the window ledge). A section of the dried cola was completely sampled by Ewing, leaving no remaining cola or surface dust on the painted surface. On an area immediately adjacent, the sample collected under the direction of Van Orden could not remove the dried cola. The attached photograph, Figure 1, illustrates this difference in sample collection.

Two additional Figures show the differing degrees of particle collection by two sampling teams collecting from the same surface. In both photographs, the differences in sampling are visually apparent.

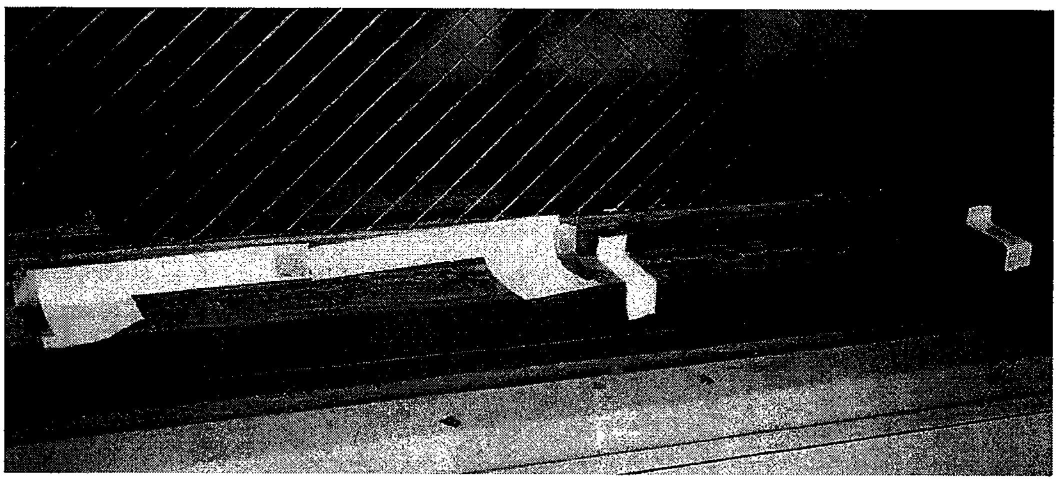

Figure 1. Photograph of the location of side-by-side microvacuum sampling collected by different personnel. The window ledge is on an interior wall where cola had been spilled and dried. The sample on the right scraped through the dried cola while the sample on the left scratched the surface but did not penetrate the dried cola.

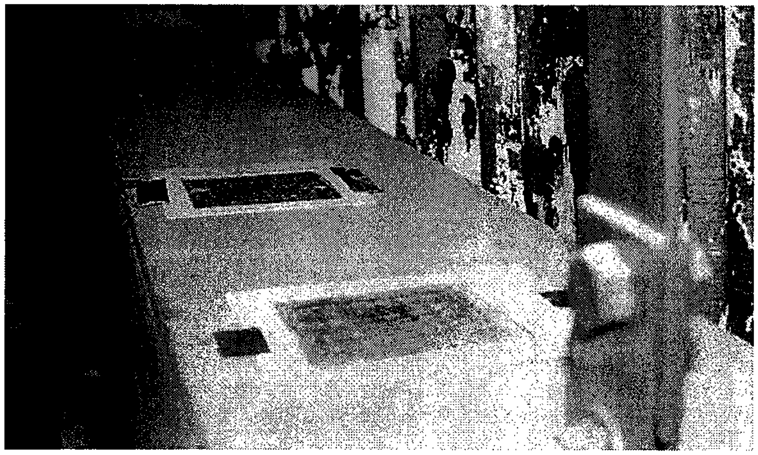

Figure 2. Side-by-side samples collected on top of a projection screen by different personnel. Both samples scraped the surface, but the top sample cleaned the surface more thoroughly than the bottom sample.

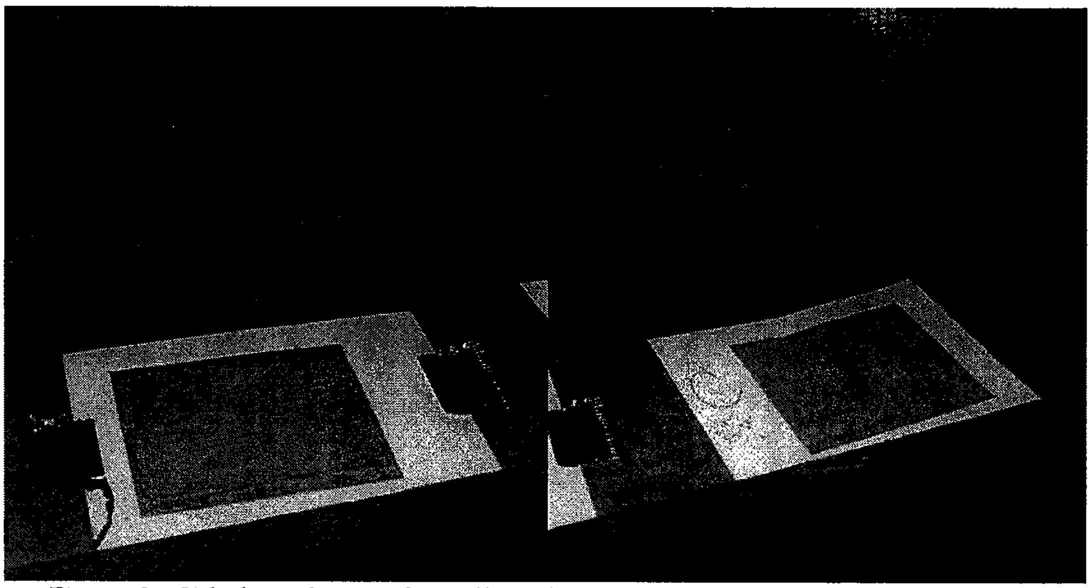

Figure 3. Side-by-side samples collected on a canopy located in a dining hall. The sample on the left removed more material than the sample on the right.

As evident in all three pictures, neither team collected the samples in accordance with the published method which states: "Avoid scraping or abrading the surface to be sampled."[7]

Thus, the process of collecting a microvacuum sample is not well defined nor is it applied in a consistent manner among individuals. These differences lead to variations in the reported asbestos structure counts.

[7] ASTM (1995). "Standard Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Concentrations", Section 8.8.

2.2 Sample Preparation

The most widely discussed and criticized aspect of microvacuum sampling is the sample preparation portion of the method. Briefly, the preparation method encompasses the following steps: 1) rinse the dust out of the sampling cassette using an aqueous solution, 2) sonicate the suspended particles, 3) redeposit an aliquot of the sonicated particles on a clean filter, and 4) prepare the redeposit filter for analysis.

The most disruptive step in sample preparation is the sonication of the sample. During sonication, high frequency sound energy is transmitted through the liquid suspension causing cavitation. Cavitation is the formation of microbubbles that, when they collapse, cause shock waves to travel through the liquid at nearly the speed of sound. At the microscopic level, sonication is a highly disruptive force that, as noted in the ASTM D5755 method, "is intended to disperse aggregated asbestos into fundamental fibrils, fiber bundles, clusters, or matrices" and "may alter the physical form of the mineral fibers".

Sonication produces uncontrolled results. No U.S. promulgated analytical method for examining air filters in buildings or for evaluating worker risk to airborne asbestos uses an indirect preparation procedure. Similarly, because of this uncontrolled effect of sonication, the official air sample procedure for France forbids the use of sonication even though the method utilizes an indirect preparation procedure.[8]

The US EPA has published a study on the effect of the indirect preparation method.[9] As noted in the Executive Summary: "... measurements made by the indirect transfer method were 3.8 times to 1,700 times higher than measurements made by the direct transfer method." Also: "There is no single factor that can be applied to convert measurements made using an indirect transfer method to a value that is comparable with measurements made using a direct transfer method."

Dr. Longo contends the use of the indirect sample preparation procedure for the microvacuum method was "chosen to provide better precision and reproducibility than if the direct method were used." In fact, it was chosen because the microvacuum sampling method required that (at a minimum) enough dust be collected to darken the sample filter, thus precluding any direct preparation of the sample.[10] A filter will darken during sample

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[8] Norme Française (1996). "Qualité de l'air: Détermination de la concentration en fibres d'amiante par microscopie électronique à transmission", NF X 43-050.

[9] EPA (1990). "Comparison of Airborne Asbestos Levels Determined by Transmission Electron Microscopy (TEM) Using Direct and Indirect Transfer Techniques", EPA 560/5-89-004, p. x.

[10] Clark, P. and Brackett, K. (1990). "Draft Test Method for Sampling And Analysis of Dust for Asbestos Structures by Transmission Electron Microscopy", US Environmental Protection Agency. As stated in

collection as more and more particles are collected. These particles will overlap, or lay upon each other, obscuring the white filter media. Because the particles are covering other particles, some collected asbestos fibers may also be obscured or covered. Thus, a direct preparation of the sample will not be able to detect these obscured fibers.

The microvacuum procedure permits the analysis of particles as large as 1 mm. The effect of processing such large particles was shown in a study in which a single large particle of chrysotile asbestos was submitted to various laboratories for analysis. (Lee reference 2) The results of these tests showed that a single large particle of chrysotile can generate anywhere from 20,000 to 22,000,000 s/cm^2 based on a sampling area of 100 cm^2. Similarly, wide ranges of results were obtained when analyzing either a 0.5 mm particle of asbestos-containing fireproofing (1,000 to 630,000 s/cm^2) or a 1 mm particle of the same asbestos-containing fireproofing (20,000 to 3,000,000 s/cm^2). These large differences in results illustrate the uncontrolled nature of the sonication procedure.

The cause of these tremendous increases in the number of particles (from one particle to millions in the above examples) is the liberation of bound fibers from matrices and the comminution of the liberated fibers into shorter, more numerous fibers. The liberation aspect is proven by the testing of the 1 mm and 0.5 mm particles of an asbestos-containing fireproofing (noted above) as well as by videotapes[11] of the sonication of particles. Even one of the Claimants' expert microscopists in the Armstrong proceeding has acknowledged that the use of the sonication procedure increases the number of asbestos fibers.[12]

RJ Lee Group has shown how sonication changes the size of asbestos fibers. Lee showed that longer sonication times produced shorter fibers (Lee reference 1). In another test, air filters collected within a single building were randomly selected for analysis by either direct preparation or indirect preparation. After a large number of filters were prepared and analyzed, the data were collated and plotted as shown in Figure 4. In this data set, between 50 and 60% of the indirectly prepared fibers were shorter than 1 μm while only 20% of the directly prepared fibers were shorter than 1 μm. The indirect preparation procedure clearly reduced the length of the fibers.

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section 8.9: "For the method to be effective, enough dust or particulate should be collected within the cassette to be visible to the naked eye."

[11] RJ Lee Group, Inc. (1993). Videotape, Ultrasonic Breakup of Chrysotile Grade 7M and Fireproofing, March 2, 1993.

[12] Keyes, D. L.; et al (1991). "Exposure to Airborne Asbestos Associated with Simulated Cable Installation Above a Suspended Ceiling", American Industrial Hygiene Association Journal, 52, p. 479 - 484. "Moreover, sonication of ashed samples may disassociate bundles and clusters and disassemble matrices, thereby increasing the total number of structures counted."

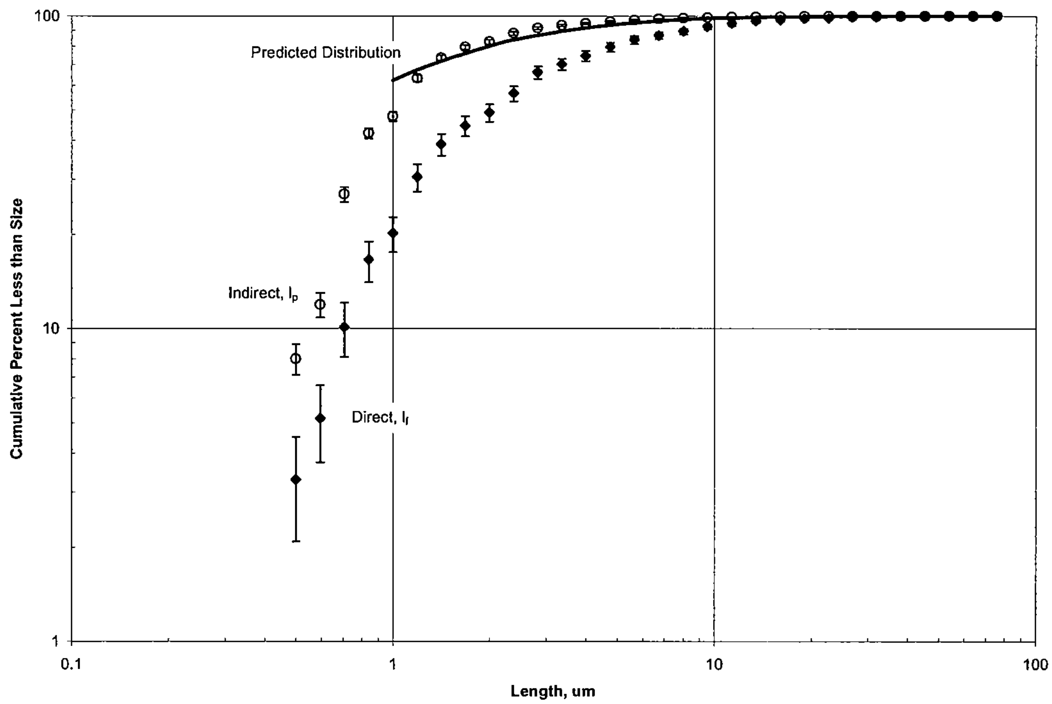

Figure 4. This graph shows the percentage of fibers that are shorter than a stated length. The Directly prepared fibers are solid circles; the indirectly prepared fibers are open circles. Error bars are plotted around each data point.

3.0 Method Reproducibility

As noted above, interlaboratory testing (sometimes referred to as "round robin" testing) of the method has shown the method to have a very large variability, enough to classify the method as non-reproducible for normal building dusts.

Dr. Longo simply asserts that round robin testing of the dust method shows it to be reproducible. Unfortunately, Dr. Longo failed to explain that all of the round robin tests conducted by MAS or on behalf of the ASTM committee are fundamentally flawed – none of the tests actually tested the entire microvacuum method. All of the round robin testing conducted by ASTM[13] was conducted on artificially prepared filters in which the test particles were subjected to sonication and deposition on filters, then sent to the participating laboratories. Therefore, the sonic disaggregation of the particles occurred prior to sending the particles to the laboratories, thus

[13] ASTM (2002). "Draft: ASTM Research Report No. xxxy for D5755". The report only mentions five rounds of testing, not the six mentioned by Dr. Longo. M. Beard, the committee chairperson, confirmed in a telephone conversation 12/13/05, that he has no report for a sixth round, only for five rounds.

effectively removing this important step in the procedure from any round robin examination.

Dr. Longo uses his own sample data[14] to suggest the method has good reproducibility. Yet, in the two sets of data discussed in his publication, the first set used a calculation procedure not permitted by the ASTM method. In the second set of data, Dr. Longo calculated the variability of the microvacuum results from within each of 38 buildings. He then averaged the 38 calculated variabilities, erroneously assuming that the resulting average is a scientifically valid representation of both the variability due to microvacuum sampling and analysis as well as the variability due to the heterogeneous nature of building dusts. In fact, it represents neither.

Dr. Longo did not measure the variability due solely to microvacuuming and vastly underestimated the variability due to the heterogeneous nature of building dusts. As noted on page 3 of this report, even with supposedly uniform dust distribution, the dust methodology results in an unacceptably high 57 - 75% variability in the data. Even assuming the microvacuum sampling technique does not materially affect the reported data, the second data set (from Hatfield, et al, reference 14) significantly underestimates the variability within the building.

As shown in Figure 5, Dr. Longo understated the variability within a building by not collecting enough samples to produce scientifically valid and reliable data. Had he collected 11 samples in every building (as in Building 1 of his data), then the variability would have been much larger than the reported 97%, possibly approaching the 214% reported for Building 1.

[14] Hatfield, R., Krewer, J., and Longo, W. E. (2000). "A Study of the Reproducibility of the Micro-Vac Technique As A Tool for the Assessment of Surface Contamination in Buildings with Asbestos-Containing Materials", *Advances in Environmental Measurement Methods for Asbestos*, ASTM STP 1342, M. Beard and H. Rook, Eds., American Society for Testing and Materials, p. 301 - 312.

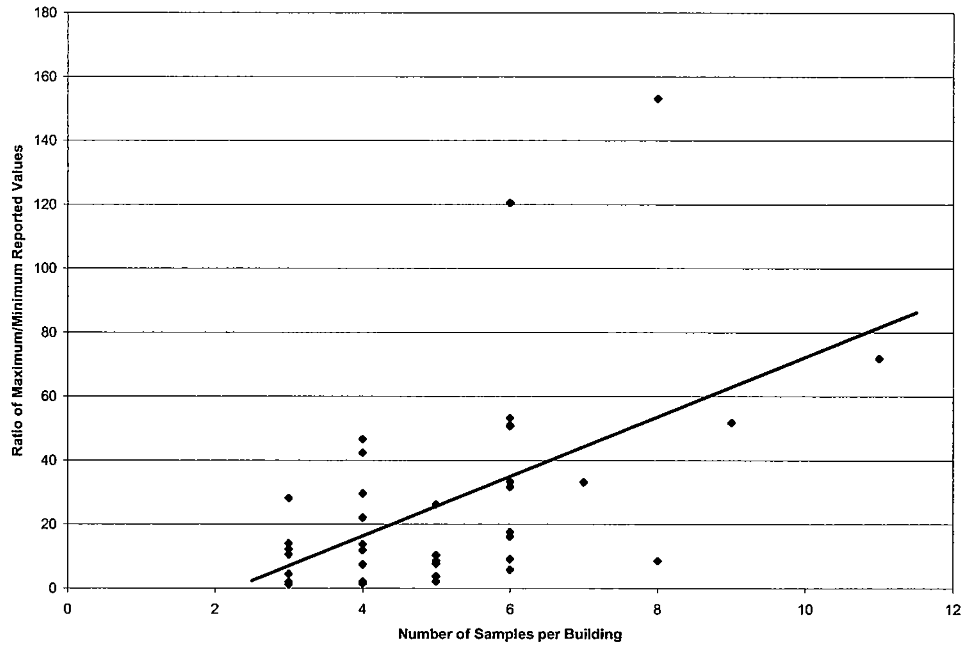

Figure 5. This graph shows that as more samples were collected and analyzed, the greater the range of data that were produced. The data were taken from Hatfield, et al.

Dr. Longo has also misinterpreted the results reported by Crankshaw, et al.[15] In that study, side-by-side samples in a basement indicated a nearly double increase in asbestos loading. Over the entire basement, the data were highly variable with one sample reporting 100 times as much asbestos as the first sample. In tests on lab-created samples, Crankshaw reported 20 times as much asbestos in one set of samples compared to another set, despite there being a 10-fold difference in deposited material.

Crankshaw also conducted a test where he deposited three times as much material in one area compared with another. In this test, the average reported result only increased by a factor of 30%. This increase in reported fiber loading occurred even though the amount of chrysotile deposited on the surface had increased by a factor of 300%. This further illustrates the unreliability of the test procedure.

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[15] Crankshaw, O., Perkins, R., and Beard, M. E. (2000). "An Overview of Settled Dust Analytical Methods and Their Relative Effectiveness", *Advances in Environmental Measurement Methods for Asbestos*, ASTM STP 1342, M. Beard and H. Rook, Eds., American Society for Testing and Materials, p. 350 - 365.

4.0 Method Development

Dr. Longo has suggested that the development of the ASTM microvacuum method consisted of nothing more than simple modifications of some non-technical issues. Dr. Longo further recalls that the "basic analytical procedure for preparing and analyzing surface dust samples did not change from the time it was first presented to the ASTM subcommittee in 1990 until its approval in 1995". Dr. Longo is incorrect in both his timeline and his recollection of the changes to the method. The following table documents some of the substantive revisions to the sample preparation portion of the method as it was developed by ASTM, beginning with the EPA draft method:

Item	EPA	6/7/89	12/5/89	1/23/91	10/1/91	11/12/91	4/9/93	1/28/94
Suspension	Ultrapure water	Ultrapure water	Ultrapure water	Ultrapure water	Ultrapure water	Ultrapure water	Ultrapure water	Particle free water and reagent alcohol
pH adjustment	1% HCl	none	1% HCl	1% HCl	1% HCl	1% HCl	1% HCl or 10% Acetic acid	10% Acetic acid
Hand Shaking, s	none	30	30	"briefly"	"briefly"	"briefly"	"briefly"	2 – 3
Sonic bath, W	"Low power"	none	"Low Power"	"Low Power"	100 – 200	60 – 100	100	100
Sonication Time, min	10	none	10	3	3	3	3	3

As can be seen from the Table, substantial changes were made to the sample preparation portion of the method during its development. These are not simply "non-technical" changes. The change from Ultrapure water to a mixture of water and alcohol was made to reduce the dissolution of gypsum in the dust samples, as acknowledged by Dr. Longo in his report (page 21: using alcohol "has the effect of not dissolving any gypsum particles or mixtures"). Similarly, the change from hydrochloric acid to acetic acid was also made to reduce the dissolution of gypsum and carbonate minerals. The sonication of the suspension changed from none to 10 minutes to three minutes. All of these changes are technical and significant. In addition, because the effect of sonication was considered to be a critical element in the method, a calibration procedure for the ultrasonic bath was added following the balloting of the 1/28/94 edition.

5.0 Use of the Microvacuum Method

The legitimate use of the microvacuum method is to document the presence or absence of asbestos fibers in surface dusts. RJ Lee Group used the method in three large projects to document the extent of asbestos in surface dust in three office buildings (Delaware Trust, 130 Liberty Street, and 4 Albany Street buildings). That testing was done in connection with insurance claims to restore the buildings to their pre-event (a fire and the collapse of the World Trade Center) conditions. In each case, the microvacuum sampling was conducted to document that dust and debris had been spread throughout each building as a result of an event and was not present as a pre-event condition. In none of these buildings was the dust sampling performed to evaluate occupant or worker safety.

In contrast, Claimants' experts incorrectly purport to use the microvacuum method for dual objectives: 1) to document the extent of asbestos in surface dust in a building (and relative amounts of asbestos); or 2) to assess the "safety" of building occupants to possible exposure to asbestos-containing surface dusts.

The Claimants' experts unscientific use of the D5755 method to determine "safety" or levels of building "contamination" is seriously flawed due to the use of the indirect preparation procedure and disregards several explicit cautions set forth in the D5755 method. As noted in the method: "as with all indirect sample preparation techniques, the asbestos observed for quantification may not represent the physical form of the asbestos as sampled". (A similar statement was included in the EPA draft microvacuum method.) More specifically, the method states: "no relationship has been established between asbestos-containing dust as measured by this method and potential human exposure to airborne asbestos". The D5755 method also "does not describe procedures or techniques required to evaluate the safety or habitability of buildings with asbestos-containing materials, or compliance with federal, state, or local regulations". The uncontrolled increase in the number of fibers through liberation and comminution makes the interpretation of the asbestos structure counts impossible.

All current risk analyses procedures incorporate direct preparation of the air filters – there is no promulgated risk analysis procedure for the evaluation of asbestos in surface dusts. Even when the EPA developed a risk analysis procedure for soils and bulk materials[16], the method was devised so that the analyzed samples were directly prepared air filters, not indirectly prepared filters.

[16] Berman, D. W. and Kolk, A. (2000). "Draft: Modified Elutriator Method for the Determination of Asbestos in Soils and Bulk Materials", Revision 1, May 23, 2000.

Because the indirect preparation procedure liberates (releases) fibers from any binding matrix, the asbestos structure counts are meaningless in terms of possible exposure.

Both Dr. Longo and Mr. Ewing suggest that the US Environmental Protection Agency (EPA) is using the microvacuum method to "make nearby buildings safe for occupancy" (Longo, page 10) at the World Trade Center. However, the COPC Committee[17] "elected against setting benchmarks for COPC [contaminants of potential concern] in settled dust", particularly for asbestos, because asbestos fibers "exert their toxicity primarily through the inhalation route of exposure". No health-based benchmarks were established for asbestos in surface dusts at the WTC site. Any benchmark created for the WTC site is strictly limited to the WTC site and is not applicable to other buildings.

Mr. Ewing suggests that RJ Lee Group agrees with the use of microvacuum test concentrations in the WTC vicinity by referring to a 2002 *USA Today* article. This reference is a misquote by the reporter who used a comment made by Dr. Lee about high airborne concentrations (reported by Chatfield[18]), not asbestos in dust, in a paragraph that discussed surface dusts.

Mr. Ewing cites to the EPA's use of dust sampling in Libby as condoning the use of D5755 by Claimants' experts. However, the EPA[19] in Libby "is not relying upon measured dust levels to decide if residential/commercial sources [of asbestos] must be addressed". After the EPA cleans a property, only visual inspection of the property and aggressive air sampling will be used to determine cleanliness. The EPA chose air sampling for clearance testing because asbestos in surface dust is not "directly correlated with risk estimates", while air concentrations directly correlate with risk estimates. (page 11)

5.1 Resuspension of Surface Dust

Both Ewing and Longo suggest that surface dust that contains asbestos may be resuspended in the air, thus causing an exposure to a building occupant or worker. They cite this action as one justification for surface dust

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[17] COPC Committee (2003). "World Trade Center Indoor Environment Assessment: Selecting Contaminants of Potential Concern [COPC] and Setting Health-Based Benchmarks", contributors included the US EPA, OSHA, and ATSDR, p. 11.

[18] Chatfield, E. J. and Kominsky, J. R. (2001). "Summary Report: Characterization of Particulate Found in Apartments After Destruction of the World Trade Center".

[19] US EPA (2003). "Libby Asbestos Site Residential/Commercial Cleanup Action Level and Clearance Criteria: Technical Memorandum", Draft Final, December 15, 2003, p. 5.

sampling. Lee[20] has investigated airborne concentrations in buildings that were allegedly damaged by the 1995 Northridge earthquake and compared these with surface dust concentrations determined using the ASTM D5755 method. As can be seen in the following graph (Figure 6), there was no correlation between asbestos in air and surface dust.

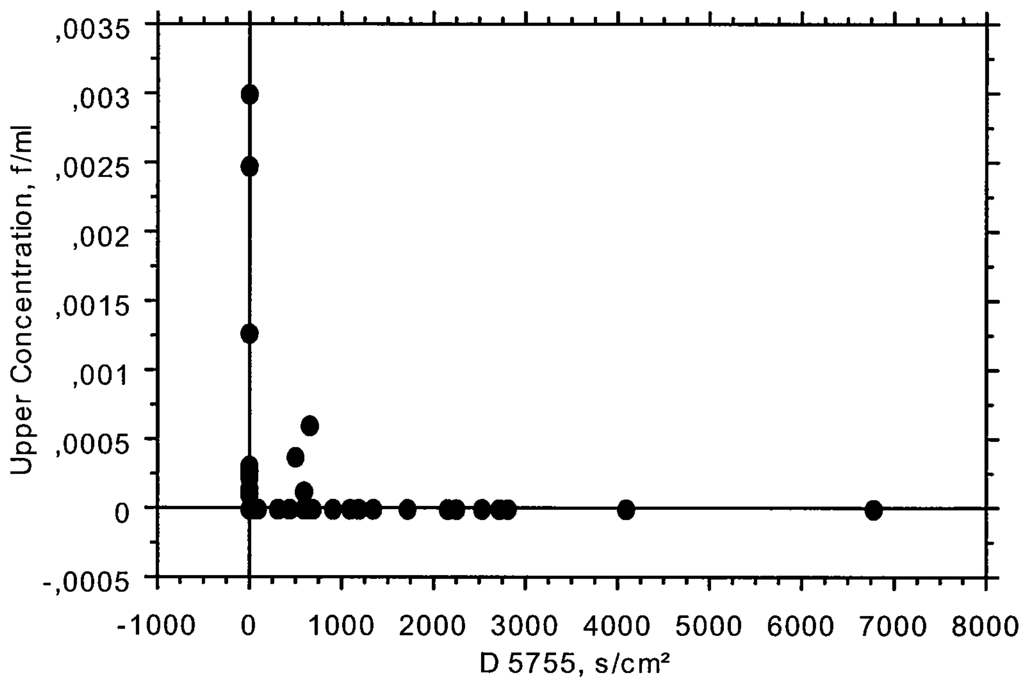

Figure 6. The correlation of airborne asbestos and asbestos in surface dust from 142 homes allegedly damaged during the 1995 Northridge earthquake.

The EPA has reported a similar graph (Figure 7) from studies they have conducted in Libby, MT. As in the Lee data, the vast majority of data points show either some reportable dust concentration with zero airborne asbestos or some airborne asbestos with zero asbestos in the surface dust. The EPA's data are shown in Figure 7.

[20] Lee, R. J., Van Orden, D. R., and Stewart, I. M. (2000). "Dust and Airborne Concentrations - Is There a Correlation?", *Advances in Environmental Measurement Methods for Asbestos*, ASTM STP 1342, M. Beard and H. Rook, Eds., American Society for Testing and Materials, p. 313 - 322.

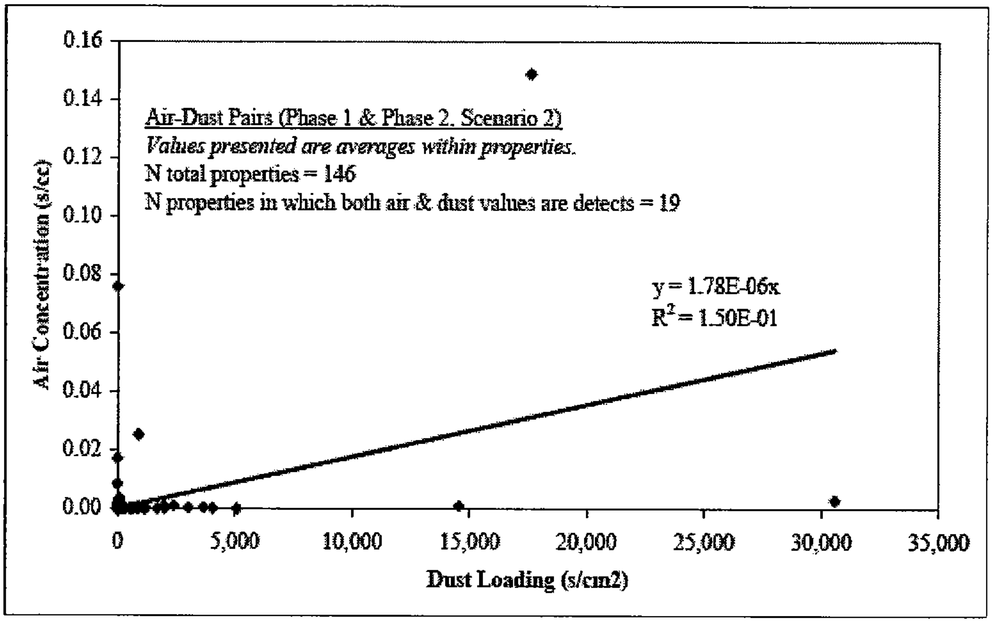

Figure 7. The correlation of airborne asbestos and asbestos in surface dust reported by the EPA from homes in Libby, MT. The vast majority of samples reported some dust loading, but no airborne concentration.

These data show there is no correlation between the amount of asbestos in surface dusts and the amount that is airborne. Because there is no correlation, there cannot be any relationship between the asbestos in surface dust and the amount that can be breathed by a building occupant or worker. These data support the statement from the ASTM D5755 method which states: "no relationship has been established between asbestos-containing dust as measured by this method and potential human exposure to airborne asbestos".

5.2 Determination of Dust Morphologies

The use of the method to suggest there are "free respirable size asbestos fibers & bundles" in the surface dust, as suggested by Dr. Longo and Mr. Ewing, is not an accepted practice. Because of the liberation of fibers from particles during the sample preparation, the analyst cannot determine whether the free fibers observed in the transmission electron microscope occurred on the surface in that manner or were liberated from larger particles during the sample preparation procedure.

RJ Lee Group tested a vermiculite-containing fireproofing material[21] to determine if free, respirable fibers became airborne as a result of hand crumbling the materials. Approximately 10gm samples of fireproofing were hand-pulverized over a 5-10 minute period until a majority of the pulverized material was smaller than 5mm. Air samplers were set up about 6 inches

[21] RJ Lee Group, Inc. (1992). Crumbling Experiment.

below and 6-12 inches laterally displaced from the point of crumbling. In addition, one sampler was located about 42 inches below with a 12 inch lateral displacement. Two samplers were placed in the debris stream directly below the point of crumbling. This arrangement permitted monitoring the air concentration during (5-10 minutes), after (20 minutes), and overall during the experiments. Over 40 experiments were conducted – no free asbestos fibers were observed on any air filter. Experiments conducted by Chatfield[22] on six asbestos-containing materials (including a fireproofing material with chrysotile, vermiculite and gypsum) support this finding.

Richard J. Lee
President

[22] Chatfield, E. (2000). "Correlated Measurements of Airborne Asbestos-Containing Particles and Surface Dust", *Advances in Environmental Measurement Methods for Asbestos*, ASTM STP 1342, M. Beard and H. Rook, Eds., American Society for Testing and Materials, p. 378 - 402. Criticisms of this test by Dr. Longo are in error. Dr. Longo does not apply the correct principles of particle coagulation as described in authoritative texts such as those by Friedlander, Hinds, and Baron/Willeke.